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AIR FORCE HUMAN RESOURCES LABORATORY

ANALYSIS APTITUDE TEST FOR SELECTION OF AIRMEN FOR THE RADIO COMMUNICATIONS ANALYSIS SPECIALIST COURSE: DEVELOPMENT AND VALIDATION

By

John J. Mathews

PERSONNEL RESEARCH DIVISION
Brooks Air Force Base, Texas 78235

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AIR FORCE SYSTEMS COMMAND
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LELAND D. BROKAW, Technical Director
Personnel Research Division

DAN D. FULGHAM, Colonel, USAF
Commander

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The objective of this study was to assess the increase in prediction of Radio Communication Analysis Specialist course performance when an Analysis Aptitude (AA) test is added to current selection instruments. Highly significant validities were obtained with AA for samples of 173 Air Force and 144 Army students. A multiple R of .7 in predicting final grades from AA and the three subtests of the Armed Forces Qualification Test (AFQT) was obtained for a subsample of 108 Army students. Minimum qualification scores of 71 percentile on AFQT and a raw score of 15 on AA were recommended for selection of students.

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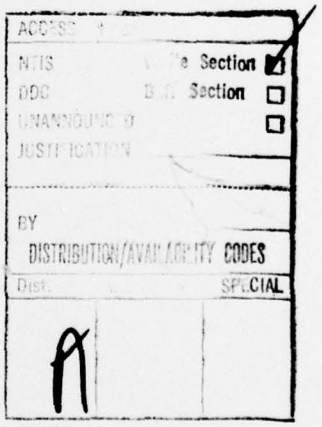
PREFACE

This research was conducted under a category –3 work effort, AFSS1000, established in response to a letter request from HQ USAFSS. Validity data were obtained from personnel at Goodfellow AFB, Texas. The contributions of these personnel and those of the Computational Sciences Division, AFHRL, including Mr. Charles Greenway and Mr. James Friemann, are gratefully acknowledged.



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ANALYSIS APTITUDE TEST FOR SELECTION OF AIRMEN FOR THE RADIO COMMUNICATIONS ANALYSIS SPECIALIST COURSE: DEVELOPMENT AND VALIDATION

I. INTRODUCTION

The Radio Communications Analysis Specialist course administered by the USAF School of Applied Cryptologic Sciences at Goodfellow Air Force Base, Texas, is the basic course for several Air Force and Army personnel specialties. These intelligence occupations require personnel of very high mental ability, and experience relatively high training attrition rates (about 20% in the 20210 course). Selection of Air Force enlistees for this career field currently includes a minimum General Aptitude Index (Gen AI) percentile of 80. The Gen AI is composed of the Word Knowledge (WK) and Arithmetic Reasoning (AR) subtests of the Armed Services Vocational Aptitude Battery (ASVAB).

The duties of Radio Communications Analysis Specialists require considerable analytical, reasoning, and verbal skills. This is apparent from the following excerpts from the Duties and Responsibilities section of AFR 39-1, AFSC 20230, dated June 1977:

> Compiles, records, and analyzes radio frequency data. Prepares and studies circuit diagrams, call signs, and operating characteristics. . . . Reconstructs radio networks and draws net diagrams in schematic or geographical design. Determines radio network schedules, personalities, and procedures characteristics. Compares and categorizes messages through analysis of message internals, externals, and other textual features.

Personnel at Goodfellow AFB have developed an Analysis Aptitude test for the purpose of supplementing the Gen AI in selection of Air Force 20210 students. The objective of this study is to assess the psychometric characteristics (especially reliability and validity) of the Analysis Aptitude (AA) test and its relationship to the Gen AI.

II. METHOD

Subjects

Three samples were utilized in the study. Sample 1 included 301 Air Force enlistees from randomly selected flights who were tested during basic training. Data from this sample were used to measure the general level of performance on the AA, AA item difficulty levels, and AA test reliability. Sample 2 consisted of 173 airmen attending the 20210 course and for whom validity data were obtained. Sample 3 was comprised of 144 Army 20210 students. This sample was used to compare AA scores with the Gen AI. Since the Air Force selects 20210 students using a Gen AI 80 percentile criterion, these scores are extremely attenuated. Corrections for restriction in range would be inaccurate unless very large samples were used. Also, the Gen AI is normally recorded in 5-point percentile intervals. Thus, only four rectangularly distributed scores (i.e., 80, 85, 90, 95) are in the range for airmen qualified for the 20210 course. Army enlistees, however, were selected on the basis of a skilled/technical composite which contains the Mathematics Knowledge, Arithmetic Reasoning, and General Science-Biology ASVAB subtests. Therefore, Gen AI scores of Army 20210 students will be less attenuated than those for Air Force students.

Predictor Variables

Some characteristics of the Analysis Aptitude test are shown in Table 1. Two sample items are given in Table A1 of the appendix. ASVAB subtests WK, AR, and Space Perception (SP) also were predictors in the study. The Air Force Gen AI is composed of WK and AR. The Armed Forces Qualification Test (AFQT), used to determine eligibility for Air Force entry, consists of WK, AR, and SP. The current ASVAB forms are described elsewhere (Jensen, Massey, & Valentine, 1976).

Table 1. **Analysis Aptitude Test Characteristics**
(Based on Random Sample of 301 Air Force Enlistees)

Number of items	22 four-choice items
Testing time	45 minutes + 10 minutes for directions
Average item difficulty (p)	.65
p range	.40 to .85
Reliability (KR-20)	.78
Mean	14.3
Standard Deviation	4.3

Training Criteria

Final grade in the 20210 course was the primary criterion. Pass/fail (P/F) status was also used, but the variance of this variable was low, due to the majority of students being in the pass group. In the Air Force sample, 81.5% passed, and in the Army sample 84.0% passed. For statistical purposes, the final grade criterion will be a more accurate indication of predictor validity for the 20210 course.

Statistical Method

All predictor and criterion information were obtained from the USAF School of Applied Cryptologic Sciences with the exceptions of those pertaining to the sample on 301 Air Force enlistees and the ASVAB subtest data. ASVAB scores came from the U.S. Army Recruiting Command file (USAREC-1), a copy of which is maintained by the Computational Sciences Division of the Air Force Human Resources Laboratory.

Analyses included simple and multiple correlations. Corrections for restriction in range were made when appropriate via formulae (Guilford & Fruchter, 1973). The F statistic was employed to test the significance of the increase in a multiple R^2 when additional predictors were used.

III. RESULTS AND DISCUSSION

Based on administration to Air Force enlistees, the Analysis Aptitude (AA) test had a mean of 14.3 and a standard deviation (SD) of 4.3. Means and SDs of study variables are listed in Table A2 of the appendix. The reliability of the AA was .78 as computed by the Kuder-Richardson 20 formula (Table 1). Levels of AA performance of the enlistees are shown in Table 2. The most frequent score was 14, and scores above 14 were achieved by 48.8%.

The validities of the AA and Gen AI for samples are presented in Table 3. High validities were obtained for AA with 20210 final grades, .58 for Air Force and .54 for Army students. Lower validities were obtained for Gen AI, .25 for Air Force and .40 for Army students. While all of these correlations (r's) are underestimates of true relationships due to attenuation effects, the Gen AI is more severely affected because of its use in screening. The validity of AA with P/F was .56 for Air Force and .40 for Army students. The r for Gen AI with P/F was .31 for Air Force and .33 for Army students.

Correlations of AA and subtests contained in Gen AI with final grades (intercorrelation matrix is in Table A3) were corrected for restriction in

Table 2. **Distributions of Analysis Aptitude Scores for Air Force Enlistees**

AA Score	Frequency	%	Cumul Freq	Cumul %
22	8	2.7	301	100.00
21	16	5.3	293	97.3
20	19	6.3	277	92.0
19	20	6.6	258	85.7
18	16	5.3	238	79.1
17	23	7.6	222	73.8
16	23	7.6	199	66.1
15	22	7.3	176	58.5
14	24	8.3	154	51.2
13	23	7.6	130	43.2
12	22	7.3	107	35.5
11	19	6.3	85	28.2
10	18	6.0	66	21.9
9	16	5.3	48	15.9
8	15	5.0	32	10.6
7	9	3.0	17	5.7
6	4	1.3	8	2.7
5	2	0.7	4	1.3
4	–	0.0	2	0.7
3	2	0.7	2	0.7

Table 3. **Validities (Uncorrected) of AA and Gen AI for 20210 Course**

Sample	N	Validity (γ)	
		Final Grade	Pass/ Fail
Analysis Aptitude Test			
Air Force	173	.58**	.56**
Army	144	.54**	.40**
General Aptitude Test			
Air Force	55[a]	.25	.31*
Army	144	.40**	.33**

[a]Subsample with ASVAB scores available.

*$p < .05$.

**$p < .01$.

range for the Army sample. Subtest data were available for 108 students. After correction, AA validity rose somewhat, from .54 to .59 (Table 4). Larger increases were obtained for both Gen AI subtests as the validity of WK increased from .39 to .58 and AR validity increased from .30 to .44. The multiple correlation (R) obtained when contributions of WK and AR were added to that of AA for prediction of final grades was .69. This represents a significant increase in prediction ($p < .01$) over that obtained with AA alone. An additional significant increase is obtained when SP is added to AA, WK, and AR, the R^2 accounting for an additional 4% of the variance. This indicates that the AFQT composite (consisting of WK, AR, and SP) could be substituted for Gen AI as a co-selection instrument along with AA.

Table 4. **Test Validities with Final Grades for Army 20210 Students**
(N = 108)

Tests	Validity[a]		Multiple R		
	γ	γ_c	Combination	R^2	F[b]
1 Analysis Aptitude	.54*	.59*	1	.35	58.1*
2 Word Knowledge	.39*	.58*	1–2	.46	21.4*
3 Arithmetic Reasoning	.30*	.44*	1–3	.47	1.8
4 Space Perception	.38*	.38*	1–4	.51	11.6*

[a] γ_c = correlation corrected for restriction in range.

[b] Test for significant increase in R^2.

*$p < .01$.

AA test frequency distributions and 20210 course performance averages are presented for Air Force students in Table 5. The most efficient AA cutoff score to use in screening appears to be 15. Ninety-seven and five-tenths percent of those scoring 15 or higher passed, and 88.2% of those with a score of 15 passed the course. Only 55.5% of those obtaining a score of 14 passed, and just 45.3% of students scoring 14 or lower passed. With a cutoff score of 15, 30.6% of the Army 20210 students would not have qualified for this course.

The probable effect of employing various combinations of cutoff scores on the AA and AFQT was estimated from data pertaining to the Army sample. If an AFQT percentile of 71 (there is no score of 70) and an AA score of 15 were simultaneously utilized as minimal selection criteria, the Army 20210 course failure rate would have been 2.9%. For the 43 students who would not have met these requirements, the failure rate was 39.5%. If the AFQT cutoff was 80 and the AA cutoff was 15, then the failure rate would have dropped to 2.3%. For the 51 students not meeting these criteria, the failure rate was 33.3%. Since all of the eight additionally screened-out students passed the course, an AFQT cutoff percentile of 71 appears to be the better selector score.

Table 5. **Performance of Air Force 20210 Students at Each AA Score Level**

AA Score	N	% Pass	Mean Grade	Cumul. N	Cumul. %
22	9	100.0	90.3	173	100.0
21	20	100.0	88.6	164	94.8
20	14	100.0	86.3	144	83.2
19	16	100.0	86.1	130	75.1
18	19	94.7	85.5	114	65.9
17	11	100.0	83.6	95	54.9
16	14	92.9	81.2	84	48.6
15	17	88.2	84.3	70	40.5
14	9	55.5	77.3	53	30.6
13	8	62.5	77.6	44	25.4
12	15	46.7	73.7	36	20.8
11	4	50.0	69.3	21	12.1
10	6	33.3	63.2	17	9.8
9	5	40.0	73.4	11	6.4
8 & Less	6	33.3	71.0	6	3.5
Total	173	81.5	81.8		

IV. CONCLUSIONS AND RECOMMENDATIONS

The psychometric characteristics of the Analysis Aptitude test appear adequate for its use in selection. The AA scores approximate a normal distribution, and the test's reliability (KR-20 = .78) is adequate for a 22-item instrument. The AA test demonstrated high validity based on 20210 course final grades (r = .58) and pass/fail (r = .56) for Air Force students. The AA, Gen AI, and AFQT tests all made significant unique contributions to the prediction of final grades. Based on analyses of Army 20210 students not highly screened on either test, it is recommended that dual cutoff scores of an AFQT percentile of 71 and an AA score of 15 be instituted in selection of 20210 students. Since the AFQT is used by all services, Army 20210 students could also be selected on this basis.

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AF Regulation. *Airman classification regulation*. Washington, DC: Department of the Air Force, 1 June 1977.

Guilford, J.P., & Fruchter, B. *Fundamental statistics in psychology and education* (5th ed.). New York: McGraw-Hill, 1973.

Jensen, H.E., Massey, I.H., & Valentine, L.D., Jr. *Armed Services Vocational Aptitude Battery Development (ASVAB Forms 5, 6, and 7).* AFHRL-TR-76-87, AD-A037 522. Lackland AFB, TX: Personnel Research Division, Air Force Human Resources Laboratory, December 1976.

APPENDIX A: SUPPLEMENTAL STATISTICS

Table A1. **Sample Analysis Aptitude Questions**

Question 1

Row X	2	3	4	5
Row Y	4	7	10	13

If row X were continued out to a value of 9, what would the value of Y be at the same relative position?

A. 16
B. 17
C. 19
D. 25

There are six post offices with ZIP codes 12188 thru 12193. There is direct mail service between 12188 and 12189, 12193 and 12190, and 12192 and 12189, 12189 and 12191, and 12190 and 12189.

Question 2

Which post office is the central office for the area?

A. 12188
B. 12189
C. 12190
D. 12191

Table A2. **Variable Means and SDs for Various Samples**

		Analysis Apt		Gen Al		AFQT		Final Grade	
Sample	N	M	SD	M	SD	M	SD	M	SD
Air Force enlistees	301	14.3	4.3	39.2[b]	– –	71.4[d]	15.8	– –	– –
Air Force 20210	173	16.2	4.0	– –	– –	– –	– –	81.8	10.5
Air Force 20210	55[a]	16.0	3.9	42.6	3.4	72.9	13.1	82.6	9.5
Army 20210	144	15.9	3.9	42.1[c]	– –	– –	– –	82.1	10.8
Army 20210	108[a]	15.7	4.0	40.8	6.9	70.8	17.4	81.8	10.6

[a]Subsamples with ASVAB scores available.

[b]Converted from Air Force percentiles.

[c]Converted from Army Standard Scores.

[d]Percentile Scores.

Table A3. **Intercorrelations of Predictors and Final Grades for Army Sample**

(N = 108, γ's Corrected for Restricted Range)

Variable	Intercorrelations			
	AR	SP	AA	FG
Word Knowledge	.76	.56	.37	.53
Arithmetic Reasoning		.59	.46	.44
Space Perception			.09	.38
Analysis Aptitude				.59
Final Grade				

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SUPPLEMENTARY

INFORMATION

AIR FORCE HUMAN RESOURCES LABORATORY
Brooks Air Force Base, Texas 78235

Errata

Number	First Author	Title
AFHRL-TR-76-87 (AD-A037 522)	Jensen	Armed Services Vocational Aptitude Battery *Development* (ASVAB *Forms 5, 6, and 7*)
AFHRL-TR-77-28 (AD-A044 525)	Hunter	Validation of a Psychomotor/Perceptual Test Battery
AFHRL-TR-77-53 (AD-A048 120)	Mathews	Screening Test Battery for Dental Laboratory Specialist Course: Development and Validation
AD-A051962 AFHRL-TR-77-74 (AD-A051 962)	Mathews	Analysis Aptitude Test for Selection of Airmen for the Radio Communications Analysis Specialist Course: Development and Validation
AFHRL-TR-78-10 (AD-A058 097)	DeVany	Supply Rate and Equilibrium Inventory of Air Force Enlisted Personnel: A Simultaneous Model of the Accession and Retention Markets Incorporating Force Level Constraints
AFHRL-TR-78-74 (AD-A066 659)	Leisey	Characteristics of Air Force Accessions: January 1975 to June 1977
AFHRL-TR-78-82 (AD-A063 656)	Mathews	Prediction of Reading Grade Levels of Service Applicants from Armed Services Vocational Aptitude Battery (ASVAB)
AFHRL-TR-79-29 (AD-A078 427)	Hendrix	Pre-Enlistment Person-Job Match System
AFHRL-TR-79-83 (AD-A090 499)	Gustafson	Recursive Forecasting System for Person-Job Match

Due to norming problems encountered with ASVAB Forms 5, 6, and 7, percentile scores derived from these test forms are in error. While the relative ranking of individuals by their percentile scores would not be affected by the norming errors, their absolute score values would be different. Therefore, descriptive statistics reported in the subject technical reports above are erroneous; other types of analyses in the report which use ASVAB percentile scores should be interpreted with caution.

NANCY GUINN, Technical Director
Manpower and Personnel Division